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Strand Plants.

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ANATOMY OF STRAND PLANTS

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INTRODUCTION

In undertaking a study of the principal anatomical and histological characteristics of a few represen~~tt~~tative types and species of sand strand (Psammophytes) and salt marsh (Halophytes) plants , it was proposed to attempt to point out and to correlate those features that would lend themselves for protection and adaptive purposes to such plants, inhabiting a region where there are such different and changing conditions as are encountered along the coast. For this work plants were selected that were not only from representitative species and families but also from the strand and marsh areas thus to show adaptations to widely diverse saline conditions.

The opinion amoung some seems to be that conditions in the sand dunes and the sandy soils of the beach are the same with reference to the amount of dissolved mineral salts as they are in the mud flats and the brackish swamps. This belief is borne out by statements made by Contejean (I) in an account of the strand vegetation in southwestern France, also by Schimper (V) in a statement made by him in Pflanzengeographie (pp 288) and by Waring (VII) who definitely states that the sand strand vegetation is halophytic. This conception however has been proven by Kearney (II) , Massart (IV) , Kelly A.P. (III) and others to be quite erroneous.

Kearney shows that not only do changes occur according to the type of soil but also to the time of year, and that also there is a slight change of soluble salts present at different levels, i.e. 3dm & 6dm.

Massart in his works carried out on the Belgian strand states that an analysis reveals that there is about 0.02%

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soluble matter per 100 parts of water andthat probably little difference is encountered unless it is on the seaward slo~~x~~pes where the spray is driven upon the beach byb the winds. Via:- It might be well to state here that the normal salt concentration in ordinary garden soil is about 0.02.

Of the two conceptions here stated the latter is undoubtedly the mère accurate and the accompanying table will show that not onlg is the latter the case but also that the sand strand plants actually are living under xerophytic conditions with to which type of plants they are frequently classed.

The following table compiled from the work of Kearney('04) which was conducted with the best instruments and equipment and with the greatest amount of care and accuracy summarizes these conditions. The table includes only some of those plants that are directly connected with this paper.

Plant	% salt at 3cm	Place made	Type of soil
Sueda maritima	1.5 -1.4	Mass	Salt marsh
Salicornia herbacea	1.5-1.4	"	Saline soil
" "	2.6	"	Saline soil
(Sueda torreyana)	3.5	Arazona	Saline soil
Cakile americana	0.03	Mass	Outermost limit of vegetation-some decaying matter present. sandy(saturated)
Atriplex arenaria			
Salsola Kali			
Honkenya peploides (Ammodenia)			
Atriplex arenaria	0.004-0.006	"	Beach-sandy
Honkenya peploides			
Salsola Kali	0.003-0.003	"	50m.from outermost line of dunes
Other determinations	0.003-0.006-0.009	"	Similar beach sand

This shows a great fluctuation in the percent of soluble salts in the sandy beach soil as compared with the saline swamp, soil. In fact it shows that the problem that The plants must combat is on the one hand an excess of dissolved mineral salts and on the other hand a dearth of mineral salts the latter probably explaining the presence of extensive root systems of the beach plants and especially in the case of the Monocotyledons . Other difficulties that the plants of the outer beach must encounter (1) Intense reflected light;(2) Intense reflected heat (3) Ocean spray carried sometimes by exceedingly heavy winds.

These plants being of necessity of somewhat a xerophytic character contrast beautifully with the halophytic plants. It was with these points in view that this problem was undertaken .

The material employed in this work was collected from the Dicotyledonous plants principally in the region of Wildwood, New Jersey.

In all cases the root , stem , and leaf were used whenever they were present. However in cases like Limonium carolinianum where the stem is such that it is impossible to procure sections from it due to the fact that the leaves are radical thus leaving no overground stem of any account, the flower stalk was used. The underground stem, rhizome,Etc. were also studied whenever they were present.

The study was conducted principally by means of transverse sections and surface sections of the leaf Etc. whenever necessary. Likewise appropriate tests were made for cell content where it was deemed advisable. For the sake of uniform material and for contrast a saffranin and light green stain was adopted. Although a few other combinations would probably have proven as satisfactory the ease and perfectness of the result of this combination

lent itself quite adequately to our purpose.

It is a peculiar privilege of the author to acknowledge his profound appreciation to Dr. Walter Steckbeck under whose able supervision this problem was conducted for much assistance and valuable suggestions and criticisms offered him during this study as well as for the suggestion of the problem itself.

Honkenya peploides Ehrh.

Honkenya peploides Ehrh. (Alsinaceae). Or Arenaria peploides L. (Caryophyllaceae). This is the sea-beach sandwort found along the eastern coast from Virginia northward; also in parts of northenn Europe and Asia. Perennial, herbaceous, with stems a foot or more in height. Erect or creeping bearing glabrous , fleshy, opposite, sessile leaves. The aerial stems atise from long rootstocks, the latter are often buried in the sand to a depth of three feet. Adventitious roots develop from the underground stem. The parts studied were the root, the buried stem , the succulent aerial stem and the leaf.

Root Anatomy:- A mature root shows in transverse section epidermis with few broken root hairs, narrow cortex of empty cells ending with the endodermis, five layers of cork cells, cork cambium which has the usual pericyclic origin , vascular tissue with the usual phloem , cambium and xylem. The bundle is diarch. In some roots the endodermis and cortex had been sloughed off as usually occurs in roots after cork development begins. Between the protoxylem arms and extending outward toword the cambium are large pitted vessels scattered through the xylem parenchyma which cells have no definite cell content.

Underground Stem:- The underground stem as we have already mentioned often extends into the sand to a depth of three feet and develops many adventitious roots , Such stems however show anatomical features that differ from the overground stem. (see fig.)

The epidermis which has been either entirely or at least in part sloughed off is followed by the cortex and a few starch containing cells along with a very well defined endodermis. All of htese are outside of a zone of four or five thin walled cells

which are suberized, brownish and show in the younger cells much protoplasmic content and are therefore sloughed off as the cork develops. Inside of the cork ring is the cork cambium and next is a wide area of phloem , a definite cambium and normal xylem region.

The most striking feature not only of this plant but also of the entire group is the decided absence of medullary rays.

Stem- Overground:- In the aerial portion of the stem the chief differences in the anatomy include a well defined and cutinized epidermis , a wider cortex of living cells, an endodermis that shows marked thickenings on the radial walls and to a slight degree on the inner tangential walls. There is also a marked absence of cork. (see fig.)

Leaf:- The leaves of this plant show the presence of stomata on both the upper and the lower surfaces but however the greater number is found on the lower surface.

Internally these leaves show many conglomerate CaC_2O_4 crystals . The palisade tissue is very loose and spongy. The bundles show a median arrangement and around each one there is a sheath of light walled parenchyma cells.

Cakile edentula. Hook.

Cakile edentula Hook. (Cruciferae) American sea Rocket. An annual, with fleshy stem and leaves, branched from a long tap root and growing very close to the edge of the ocean, in fact as near to the water as any other flowering plants. It is found on the shores from Newfoundland to Florida, along the shores of the Great Lakes and also on the coast of California.

The fruit of this plant is also of some interest because the pod when ripe is divided into two joints. The upper joint slightly longer than the lower is ovoid,flattened and narrows into a beak above, while the lower joint is obovoid and not flattened. It furthermore is an indehiscent fruit which is unusual for this family.

The anatomical features as determined from transverse sections of the respective parts- root,stem, and leaf, are principally as follows.

Root:-

There is little found in the root that can be considered to be of any great divergence from the typical structure. Going from the exterior inward we note a well defined cork area, which has been derived from an equally well defined cork cambium. A false cortex just before the phloem region , which is itself quite prominent and appears to be from 6 - 8 cells wide on the average. The xylem on the inner side of the cambium contain considerble numbers of pitted vessels. There is also shown quite wide and prominent medullary rays.

Stem:-

The stem shows a large cortex, A characteristic epidermis having a relatively heavy cuticle and remarkably strong thickenings on the inner walls. The bast fibers further toward the interior of the stem are slightly lignified. There is also the usual phloem, xylem, and cambium and many prominent protoxylem arms and a considerable area of pith. Any additional minor details of structure are the same as are seen in other normal stems.

Leaf:-

The leaves have present, stomata, on both the upper and lower surfaces and internally have a loose palisade on both sides with a spongy mesophyll ~~like~~ tissue between these two layers and which in turn contain the bundles.

Scattered through the epidermal layer are numerous enlarged cells which seem to function as water storage cells . We likewise note numbers of other peculiar cells that give all indications of being myrosin cells rather than mucilage cells. We would however conclude that they are the former not only from their structure but also from the fact that they have been found frequently in several other members of this group and even of this genus.

Euphorbia polygonifolia L.

Euphorbia polygonifolia L or Chamaesyce polygonifolia L (Euphorbiaceae), the seaside or knotweed spurge, is an annual which grows very close to ocean where it is constantly washed over by sea water. The plant branches from the base and is spreading and prostrate. Leaves are small and opposite. This plant is found along the coast from Rhode Island to Florida and also on the shores of the Great Lakes.

Root:- The anatomy of the mature root is practically normal. From the surface are found in succession, cork, phellogen, a narrow phelloderm (or aerenchyma?), small amount of phloem, bundle cambium, xylem. There is slight evidence of medullary rays.

Stem:- The stem shows a definite epidermis with heavy cuticle and the inner walls of the epidermal layer strongly thickened. The cortex comprises an area of 10 to 14 cells wide, with an outer collenchyma the walls of which are slightly thickened. In the inner cortex are large latex tubes. Well-defined bast fibers are scattered through the pericycle. The soft bast forms a narrow zone and is followed by the cambium and the xylem with its large pitted vessels and prominent protoxylem arms projecting into the pith region.

Leaf:- The epidermis shows strongly-cutinized outer walls and thickened tangential walls. In contrast to most of the species of halophytes examined the seaside spurge has stomata on the lower side only of the leaf. There is no definite palisade on either side but in its place are loose mesophyll cells. The prominent chlorenchyma cells are grouped radially around the bundles, and densely filled with chloroplasts. The bundles are small, collateral and medianly arranged. Latex tubes are scattered through the mesophyll, but most abundant near the bundles. Papillose, water-storage cells are noted in the lower epidermis.

Salsola Kali L.

Salsola Kali L. The prickley glasswort or Russian thistle an annual, plant branching profusely and bearing prickle pointed, subulate leaves which are terete in cross section. It grows in the drier sand and usually near the ocean and is found plentifully in both hemispheres.

Root ;- There is found in the mature root, cork , cork cambium, a very small amount of phelloderm and bundle tissues.

The arrangement of the bundle tissues is quite similar to that of many other members of this family which show anomalous structure. The development begins with the normal diarch structure. After a short time the bundle cambium develops in the pericycle. This then forms xylem and phloem with quantities of thick conjunctive tissue between the conductive vascular elements. This development of accessory bundle development continues and the final appearence of the root is quite different from that of the average root structure.. The resultant condition is that there are then patches of phloem and functionless cambium scattered through the root with a ring of functioning cambium at the periphory of this anomolous development. There are no medullary rays formed.

Stem:- (Plate I fig III) The stem still carries out a similar development as that just seen in the root. The cells of the epidermis show heavy cuticle on the outer walls as well as heavy thickening on the inner tangential walls, also the regular ring of epidermal cells are frequently interrupted by the presence of stomata in addition to the development of ribs of collenchyma cells that extend into the projecting surface ridges of the stem Immediately beneath the epidermis is a layer of chlorenchyma cells

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(Ph.- fig II). Next and abutting against this chlorenchyma layer is a layer of starch containing cells. These cells form a single layer and are arranged with their longer axes at right angles to the longer axes of the palisade cells. The middle and inner cortex is of large thin walled cells that contain many scattered conglomerate crystals. The cortex is then followed by a bundle cambium which as in the root functions only in a centripetal direction, forming xylem, phloem and conjunctive tissue on the inner side. Projecting into the large pith are many protoxylem arms.

Leaf:- (Plate I - fig. I) The leaf circular in outline shows again the reguler epidermis with the characteristic wall thickenings. On opposite sides of the leaf appear also patches of collenchyma with projecting surfaces thus forming ridges. As usual many stomata are seen. Directly under the epidermis is a narrow layer of chlorenchyma and a layer of starch containing cells similar to that seen inthe stem with the same arrangement but slightly more prominent. At the junctions where these rings of starch cells and chlorenchyma are interrupted by the collenchyma ribs there appear small patches of bundle elements. Directly in the center of the leaf is situated the mid rib bundle of normal development, and surrounded by a large area of aqueous or aerating tissue of large thin walled cells.

Dondia Maritima (L) Druce.

Dondia maritima (L) Druce or Sueda maritima Dumort (Chenopodiaceae), the annual sea-blite. One of the typical halophytic plants inhebiting regions along the sea beaches ,sandy and muddy shores and in the salt marshes, where according to Kearney and others the salt concentration is rather high.

Dondia (or Sueda) has a rather wide distribution being found on the shores from Quebec, to New York, New Jersey and southward as well as on the shores of Northwestern North America and in Europe.

Root:- The root structure shows the characteristic anomalous development seen in so many members of this group. The cork is developed normally from the pericyclic cork cambium and which by its development has sloughed off the epidermis and the cortex. However beneath the so formed cork is a narrow false cortical region. The bundle cambium formed similarily as that in Salsola commences as a normal diarch bundle with functioning cambium which lays down ,phloem , xylem and conjunctive tissue. This development continues periodically with the result that the root does not appear at all like the characteristic normal structure,- there appearing patches of functionless cambium and phloem surrounded by xylem and conjunctive tissue.

Stem:- Epidermis of cells witht the usual outer and tangential wall thickenings and a few stomata is seen followed by a ring of chlorenchyma- discontinuous because of the development of ribs of collenchyma. In the region of these ridges the chlorenchyma is much more diffuse than otherwise.

The cortex which is composed of rather thin walled cells has on its inner side a somewhat poorly defined endodermis and in the region of the pericycle bast fibers are formed followed by a cambium that shows a condition similar to that encountered in Salsola thus being in general that type of development seen in the root The extensive pith area that occupies the central portion of the stem has projecting into it many quite prominent protoxylem arms.

Leaf:- The leaves are small, fleshy, and obtusely triangular in outline. The epidermis with similar characteristic protection as others studied shows many papillose cells, a condition more marked on the upper surface than on the lower. Stomata are present on both surfaces, although more numerous on the upper, In conjunction with well defined double palisade scattered through which are mucilage sacs that envelope large numbers of raphides. These are contained in cells that are abundant in both the ab- and adaxial sides of the leaf. In addition to the bundles of raphides that are imbedded in the mucilage ,any other crystals are seen distributed through the mesophyll as well as in the upper and lower epidermis.

Atriplex hastata L.

Atriplex hastata L. Halbert-leaved Orache, an annual growing in more of a saline soil than Atriplex arenaria. It is found in the salt meadows and waste places being most abundant near the coast and in distribution from Nova Scotia to South Carolina.

Root:- The cork which shows a normal development that is coming from the pericycle, has by its development sloughed off the cortex and the epidermis but however beneath the cork is a narrow area of aerenchyma tissue.

As is characteristic of this group the bundle has developed as a diarch, the cambium laying down the usual phloem, xyem and conjunctive tissue this then periodically becomes functionless and a new cambium arising in the pericycle and it following the course persued by the first; thus in the older root patches phloem and functionless cambium are seen scattered through the vascular cylinder surrounded by xylem and conjunctive tissue. There are present large pitted vessels and no pith.

Stem:- The epidermal cells have developed heavy cutin thickenings on the outer walls as well as heavy thickenings on the inner walls. An unusally large number of stomata, slightly sunken , are seen. Immediately under the epidermis is a continuous layer of chlorenchyma interrupted only by the presence of well developed protruding ribs of collenchyma cells. The cortex two to five cells wide contains many conglomerate calcium oxalate crystals. Numerous and large patches of bast fibers are seen developing in the pericycle and following this is a small cambium the development showing the same type of structure as seen in the root. The pith area has protruding into it prominent protoxylem arms and at times almost entire bundles.

Leaf:- In the epidermis which has developed similar protective t

thickenings as seen in the stem, are sean very slightly sunken stomata as well as numerous papillose cells. There is no distinct palisade formed but however layers of chlorenchyma are present om both sides. The median portion of the leaf which lies between the layers of chlorenchyma is made up of loose mesophyll and the small collateral bundles, the midrib bundle being much larger that any of the others. Distributed generally throughout the leaf are quantities of conglomerate crystals.

Atriplex arenaria Nutt.

Atriplex arenaria Nutt (Chenopodiaceae) The sea beach Atriplex, an annual, profusely branching, and bearing rather small oblong leaves that carry the flowers in their axils. In range it is found on the shores from Massachusetts to Florida.

Root:- The cork here has developed normally and in so doing has sloughedo off the epidermis and the cortex, however beneath the cork ring is an area of false cortex in the form of aerenchyma tissue which has been formed by the bundle cambium. This unusual development of tissue on the outer surface of the cambium in noted in other members of this family, especially in species of Salicornia and Dondia.

Following the continuous ring of cambium is noted again that usual anomalous development of xylem , phloem and conjunctive tissue as seen in Salsola, Sueda (Dondia) and Atriplex hastata.

Stem:- The epidermal cells have a heavy cuticle laid down on its outer surface in addition to heavily thickened inner walls. The presence of stomata is also noted regardless of the fact that there is absolutely no trace of chlorenchyma and that the outer cortex has developed a quantity of well marked collenchyma. In other respects the cortex is normal and contains many conglomerate crystails.

The patches of bast fibers of which there are not a great many are distributed through the pericycle. The cambium on its inner side has developed complete bundles each with xylem and phloem arranged collaterally and with the vascular strands surrounded by conjunctive tissue. As in other members of the Chenopodiaceae there are no medullary rays developed . The central

portion of the stem is occupied by a large amount of pith in the cells of which many large conglomerate calsium oxalate crystals are found similar to thoes in the cortex.

Leaf:- As usual the epidermis shows the heavily thickened outer walls. On the outer surface quantities of large papillose cells appear and have taken the form of rounded spherical hairs. These cells are more pronounced in size and abundance than any other plant examined. Stomata appear on both sides . No definite palisade has been differentiated but however there is definite mesophyll present.

Sheaths around the bundles as in Euphorbia are composed of chlorophylloid cells. These cells are filled with chloroplasts and also through the mesophyll few chloroplasts are scattered but however these are more abundant in the regions of these chlorenchyma sheaths. Distributed through the leaf crystal cells are seen and are very much enlarged over those of the mesophyll cells and contained in these are many large,beautifully formed conglomerate crystals.

Oenothera humifusa Nutt.

Oenothera humifusa Nutt. or Raimannia humifusa Rose (Onagraceae) the sea side evening primrose, a low somewhat spreading plant branching from the base and usually above, with both leaves and stem covered by many very small white hairs. The plant itself ascending from a long tap root which is developed for some distance down into the sand. The stem is quite tough although the leaves are somewhat thickened- slightly lobed and bear the yellow nocturnal flowers in their axils. The plant is found along the beaches ranging from New Jersey to Florida.

Root:- The internal anatomy of this species proved intensely interesting principally because of the variations as compared withb those types previously studied. The histological structure of the mature root,takeni in September, showed on the surface a narrow zone of poorly defined cork followed immediately by a false cortex which abutts against a narrow area of phloem. In the cortex are found many large crystal containing cells. The crystals are generally blunt rods but however in some sections there are many which are longer, pointed and wider than the usual raphides found in plants.

There is also seen a very definite and continuous ring of cambium giving rise on its inner side to an area of xylem which shows rather clearly a tetrarch condition . The metaxylem of which thereis a wide zone, has many pitted vessels scattered through it. The wood fibers are thin walled and not very clearly indicated . Large and quite distinct medullary rays are present.

Stem:- The older and younger type of stem have both been studied. The former being cut from near the top of the stem and the latter from near the bases of the stem both areas being taken

from the same plant.

In the structure of the younger stem there is seen a well defined epidermis from which there are sent out numerous large hairs each coming from a large molticellular base, the shaft being of one or a few cells long and one cell wide with walls thickened on all sides.

The outer cortex is composed of chlorenchyma cells and a few scattered muscilage canals. Then in the medio-cortex there are scattered bundles of raphides. Next in the pericycle there appear the bast fibers which are slightly lignified in this stage and contain much living content. Besides this there is also a ring of soft bast, a ring of cambium and a ring of xylem. An interesting and anomalous character of this stem is the development of small patches of internal phloem that are scattered and extend into the outer pith area.

The older stem taken from the base of the same plant as was the younger.show a development of cork in the pericycle. The epidermis andc cortex cells about to be sloughed off. Next to the epidermis the compressed and now narrow cortex and also in this region some tannin and many mucilage cells are found. Then successively - a well defined cork zone comoosed of large thick cells , a quite narrow area of phloem formed by the cambiun as well as a wide xylem region. As was also noted in the younger stem there are observed patches of internal phloem portions of which extend into the outer pith. Raphides are noted distributed through the pith cells.

Leaf:- The epidermis of the leaf also shows large hairs of the same type as those found on the stem- that is - either few celled or unicellular with multicellular bases and the cells of the shaft being thickened on all walls. There are stomata on both

surfaces with their guard cells directly exposed at the surface. There is also palisade shown on both the upper and lower sides, that on the upper being slightly wider than that on the lower. A very striking and prominent feature of this leaf is the presence of many large cells containing raphides, with each cluster of crystals being enveloped in a thick sheath of mucilage. These cells are scattered through the palisade and are parallel with the chlorophylloid cells of the palisade but much larger. The bundles arranged medianly are small and show the usual structure.

Limonium Carolinianum (Walt.) Britton

Limonium carolinianum (Plumbaginaceae) an ocean side plant abundant in salt marshes where it is frequently covered over by sea water. This is an American plant found along the Eastern seaboard from the Labrador to Florida and Texas. It is a perennial with a thick fleshy tap root, no definite stem and a rosette of large leaves. From the center of the rosette arises the floral axis to a height of a foot or more.

Root:- (Plate II fig. VIII) There is a definite cork which has developed from a well defined cork cambium which in turn has sloughed off the epidermis and the cortex. A wide area of phelloderm which is not clearly separated from the next zone, the phloem. In this plant as in certain others it is difficult to determine how much of this tissue , between the cork cambium and the bundle cambium is formed from the phellogen. Or is it all developed from the bundle cambium? The main function, apparently, of the outer portion of this area is for aeration (aerenchyma). The bundle cambium is followed by the xylem with the usual conducting and mechanical elements. The bundle is a diarch.

Stem (Floral axis) (PlateII fig.VI) Here one first notes an epidermis of small cells heavily thickened on both the outer and inner tangential walls followed by a relatively small cortical area which ranges from ten to twelve cells in depth. Then the phloem and cambium which normally should appear next ,does not, except for a small patch of cells which appear now and again in various sections . However the following explaination seems to lend itself- namely that in the younger plants or rather in the younger stages of the floral axis there is developed a normal cambium and phloem but as the season advances these are lost and are replaced by

heavy lignified tissues throughout which are scattered many large and small collateral bundles. (Co.B. fig VI) . Inside of this area of lignified tissue which forms a ring of varied depths are medullary semiconcentric bundles and a large region of pith. Although there is no chlorenchyma present in the axis nevertheless there are scattered through the epidermis slightly sunken stomata.

Leaf:- The leaf structure appears quite normal showing stomata on both sides with by far the greater number on the upper side and with a good palisade on the lower side and a rather poor one on the upper. Also scattered through the leaf are many crystals - small cubical as well as conglomerate.

The bundles are medianly arranged , are simple collateral and with a light parenchyma sheath surrounding each one. The epidermal walls are well cutinized and as usual show the heavy thickenings on the tangential walls also, and on the lower side the epidermal layer is followed by a row of definitely arranged cells. Amoung the epidermal cells are also seen many enlarged cells, ~~probably buloid cells,~~ that is , water storage cells. also in addition to the crystals that are distributed through the leaf there is much tannin and mucilage, as determined by microchemical tests.

Solidago semperverens L

Solidago semperverens L (Compositae) (Plate I; fig III - V) . The sea side golden rod, a perennial found on the salt marshes, sea beaches, along tidal rivers and in sandy soil near the sea from New brunswick to Florida and Mexico and also in Bermuda.

Root:- The epidermis is composed of very heavily thickened cells and is followed by a cortex that is made up of loose and aerenchyma like tissue. In the inner cortex close to the endodermis are found generally five oleoresin canals. Each canal stands out quite strikingly and is lined with a layer of secreting cells. The endodermis and pericambium are also very well developed. The phloem of which there are five patches developing from the pentarch bundle abutts against the pericambium. The bundle cambium forms the usual bundle elements. The central portion is occupied by only a small amount of pith.

Stem:- The epidermis again shows the characteristic protective thickenings and immediately beneath it is developed. The ordinary cortex likewise composed of loose aerenchyma like tissue, the cells of which , contain a small amount of cell content. Through the cortex are scattered many small oleoresin canals which seem to be arranged in two regions;- one ring of small canals just inside of the epidermis and the other just outside of the principal ring of bundles. They are also seen in connection with the cortical (leaf trace) bundles that are distributed through this region. The cortex ends in an endodermis which is quite clearly shown, as it is in so many stems of the Compositae. Following the endodermis is seen the exceedingly well developed hard bast, then the soft bast, bundle

cambium, and the xylem. In the outer pith and rather closely associated with the bundles is another ring of oleoresin canals these being much larger than those in the cortical region. Occasionly there is seen a similar canal deeper in the extensive pith region bu this however in not generally the case. Developing on the inner side of the bundles is observed a decided medullary sheath.

Leaf:- The characteristic protective thickenings are again seen on the epidermal cells and scattered through them is a considerable amount of cell content. From depressions in the epidermis arise well marked trichone hydathodes (solitary) (Plate I; fig III) as well as stomata but the latter however are in the same plane as the epidermal cells. The palisade which is of a somewhat spongy nature is formed on the upper and the lower sides the two layers meeting in the median portion of the leaf thus eliminating any definite loose mesophyll. The bundles are also medianlly arranged and directly associated with each is a small oleoresin canal. The bundle structure shows the normal collateral condition.

Baccharis halimifolia L.

Baccharis halimifolia L. (Compositae), the groundsel-tree or -bush, also known as the pencil tree. It is a branching shrub which is found flourishing not only as a halophyte but extending at times much beyond saline influence. It is distributed along salt marshes, as well as extending sometimes some distances inland, from Massachusetts to Florida and Texas.

Root:- The structure of the root reveals nothing striking or anomalous. The cortex made up of rather loosely arranged cells showing the presence of a few oleoresin canals forms the outer area. The cork in this particular root is developed superficially instead of coming from the pericycle. The endodermis and the pericycle are well indicated in the younger roots and are still recognisable in the older stages.

The bundle cylinder shows clearly a tetrarch system with a large amount of metaxylem. Next the cambium which forms a continuous ring; the soft bast, and arranged in the pericycle are large patches of hard bast..

Stem:- The outer wall of the epidermis are exceedingly heavily cutinized and the inner ones although they are thickened t the degree of thickening is much less than that of the outer walls. There ~~are~~ is a plentiful number of stomata present and these are raised decidedly. Groups of multicellular hydathodes are seen arising from depressions in the epidermis, similar to those in the leaf. Just under the epidermis is a region of chlorenchyma~~s~~ and a cortex of loosely arranged cells that probably serve for aerating purposes. In the region of the pericycle and directly in front of the bundle are patches of very heavy bast fibers many of which have associated with them small resin ducts or canals that are lined with secreting

ing cells. Between theseand the bundle cambium are especially well developed phloem patches. The bundles show, the typical Dicotyledonous structure. Around the portions of these bundles which border on the large pith area marked medullary sheaths are formed. In the older stems cork develops normally.

Leaf:- The outer walls of the leaf are well cutinized but the thickenings on the inner ones are not as well, marked as those on the outer walls.

Both surfaces of the leaf give rise to stomata which are on the same level as the epidermal cells. From depressions in the epidermis arise groups of multicellular hydathodes. Apalisade has been developed so as to form a continuous ring being interrupted only in the region of the midrib. Through the median portion, that is between the upper and the lower layers of the palisade, the loose mesophyll and bundles are confined. Few oleoresin canals are observed which again seem to be associated with the bundles.

SUMMARY

In the general morphology of those plants studied of which there were eleven species representing eight different families, all Dicotyledons, the main features include a slight development of succulency of the stem in such types as Cakile and Salsola, the leaves are thicker in these strand plants than in the typical mesophytic forms, or the leaves may be reduced in size as they are in Dondia and Salsola, those of the latter being cylinderical in shape.

From an histological stand point the comparison of the root structure amoung the several types studied, it seems apparent that the structure follows that which is characteristic of the respective family or genus, and that little if any change or modification is brought about to cope with the environmental ch changes. The cork has a pericyclic origin except in Baccharis halimifolia where it is superficial.

In the stem the respective group characters as displayed in the root are quite frequently carried out as far as the vascular development is concerned. However there seems to be a connectiion between the size of the leaf, and thereby the amount of transpiration surface, and the presence of stomata and chlorenchyma in the stem.

It is further noted that in the submerging of the stem in the sand, as in Honkenya, the epidermis, cortex and endodermis are all sloughed off by the development of cork which originates in the pericycle.

The leaf however shows the greatest number of varied changes. For all species studied it was observed that a double palisade

or chlorenchyma was developed and stomata were present on both sides, never sunken, orm atb the most only slightly, there being only one exception where stomata were present on only one side of the leaf, (Euphorbia) In the case of two species of Compositae where hydathodes were also present arising from depressions in the epidermis. In both the stem and the leaf the epidermal cells show universally heavily-cutinized outer walls as well as heavily thickened tangential walls.

In Euphorbia polygonifolia and Atriplex arenaria the chlorenchyma form dense sheaths around the bundles. This is apparently an attempt on the part of the chloroplasts to retreat away from the light as far as possible.

Calcium oxalate crystals of varied shapes are found in practically all of the species examined with two exceptions.

CONCLUSIONS

I- Roots show little or no change of structure with respect to environment.

2.- Reduction of surface area in the Leaf to carry on the excess transpiration is compensated for in the stem by the frequent development of chlorenchyma and stomata.

3.- The vascular structure of the stem shows a similar development as that of the root of the respective plant groups.

4.- Chloroplasts in the leaves of Euphorbia polygonifolia and Atriplex arenaria retreat as far as possible from the strong light and arrangem themselves in the regions of the bundles.,

5.- The leaves show stomata on both surfaces. Papillose , water storage cells, are common in the epidermal layers. A double Palisade Layer area is the rule.

6.- Aerenchyma develops frequently in roots and in stems where these are submerged in water or buried in sand.

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Explaination of Plates

Abbreviations: Tx, cortex; Ch, chlorenchyma; Sl, starch containing cells; C, cambium; P, phloem; H, hydathode; RC, resin canal; ScB, semiconcentric medullary bundle; CC, cork cambium End, endodermis; PtX, protoxylem; MR, medullary rays; B, patches of bast fibers; Bf, bundle fibers Co, collenchyma ; Py, pericycle; Ph phelloderm.

PLATE I

Fig I- Transverse section of leaf of Salsola Kali. (Ch) - collenchyma next to epidermis (Sl) followed by starch containing cells (Tx) cortex (Co) collenchyma (Bf) bundle fibers.

Fig II- Section of T.S. stem of S. Kali (P) phloem surrounded by xylem and conjunctive tissue (Co) the collenchyma ribs (Sl) layer of starch cells between epidermis and (Ch) chlorenchyma interrupted by (Co) the collenchyma ribs (C) cambium

Fig III-T.S. of leaf of Solidago semperverens (H) hydathode and (RC) resin canal closely related to the bundle.

Fig IV- T.S. of root of S. semperverens (RC) resin canals (End) endodermis (Py) pericycle (Tx) cortex (P) phloem (C) cambium .

Fig- V T.S. stem of S. semperverens (PtX) protoxylem (P) phloem (C) cambium (RC) resin canal.

PLATE II

Fig VI- T.S. Floral axis of Limonium carolinianum (Tx) cortex (C) cambium (ScB) semiconcentric medullary bundle.

Fig VII- T.S. Stem of Atriplex Hastata (PtX) prominent protoxylem (B) patches of bast fibers (C) cambium (P) phloem (Tx) cortex.

Fig VIII- T.S. Root of Limonium carolinianum (Ph) phello-

derm (MR) medullary rays arising (CC) cork cambium .

Fig IX- T.S. Underground stem of Honkenya peploides (Cx) cortex(CC) cork cambium arises (End) endodermis (P)phloem (C) cambium.

Fig X- T.S. Overground stem of H. peploides(Ph) phelloderm (End) endodermis (Tx) cortex

Fig XI- T.S. Stem of Euphorbia polygonifolia (PtX) protoxylem (P) phloem (C) cambium(Tx) cortex.

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